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ABSTRACT

This issue, part of an annual series prepared for Maryland educators, presents the problem solving aspect of learning behavior by reviewing some of the variables which affect how individuals confront intellectual problems. Selected studies and a bibliography which are helpful in developing instructional methods which take into account individual differences in problem solving behavior comprise the bulk of the report. Studies reviewed are categorized under five headings: (1) problem solving strategies; (2) the use of verbal cues and mediational processes; (3) developmental changes in conceptual behavior; (4) cognitive and personality factors in problem solving; and (5) sex differences in problem solving. (TL)

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problem solving behavior

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parameters of individualization
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preface

Educators are continuing to devote considerable attention to problems of the individualization of instruction. Keeping to its established purpose of presenting Maryland educators with selected, research-based findings, the "Abstracts" brings together reports of studies dealing with another aspect of learning style in individualization — problem solving behavior.

We hope that educators will find the abstracts valuable. The Department also hopes that readers will suggest ways to make the series more useful and will recommend topics for inclusion in future issues.

James A. Sensenbaugh

James A. Sensenbaugh
State Superintendent of Schools

foreword

The Division of Research, Evaluation, and Information Systems of the Maryland State Department of Education is pleased to present *Parameters of Individualization: Part II, Problem Solving Behavior*, the fourth volume in the series, "Abstracts of Educational Research."

The issue was written by Phyllis M. Sunshine and Mary M. Suydam under the direction of James B. League, Consultant in Research.

We hope that the "Abstracts" will continue to be of use to members of the educational community in Maryland.

Richard K. McKay

Richard K. McKay
Assistant State Superintendent in
Research, Evaluation, and Information Systems

introduction

The "Abstracts of Educational Research" are prepared annually for educators by the Division of Research, Evaluation, and Information Systems of the Maryland State Department of Education. Volume IV, *Parameters of Individualization,* focuses upon research topics which are relevant to the problem of the individualization of classroom instruction. "Part I, Cognitive Style," of the volume contains abstracted studies of characteristic response modes of information processing used by human subjects. The present issue, "Part II, Problem Solving Behavior," presents another aspect of learning style by reviewing some of the variables which affect how individuals confront intellectual problems. The purpose is not to present an exhaustive review of the literature on problem solving, but to present selected studies and a bibliography which may be helpful in developing instructional methods which take into account individual differences in problem solving behavior.

Before instructional methods can be tailored to the individual differences of learners in problem solving situations, the term problem solving must be clearly understood. Even though research on human problem solving has been carried on for many years, a controversy still exists over the definition of the term and the types of behavior which should be included in problem solving. All of the following have at one time been included under the generic term of problem solving: creativity, guided and independent discovery, convergent thinking (i.e., problem situations where there is one correct answer) and divergent thinking (i.e., problem situations where there is no one correct answer). Although most researchers would disagree as to which of the above behaviors should be included under the rubric of problem solving, many would agree with Gagné's definition (1966) that:

> Problem solving is an inferred change in human capability that results in the acquisition of a generalizable rule which is novel to the individual, which cannot have been established by direct recall, and which can manifest itself in applicability to the solution of a class of problems.[1]

When an individual is confronted with a problem he must choose an operation or strategy to find the solution in a logical manner. Sometimes the problem defines a number of discrete and interlocking substeps which need to be mastered before the total problem can be solved. Other problems yield no clue to even the preliminary steps. Thus, a learner should choose a strategy which effectively will lead to a problem's solution. A strategy is called efficient when only the essential or relevant information is focused upon. Hence, an efficient strategy is one which leads to the correct answer in the fewest steps. And, it is this choice of an efficient strategy which causes one source of variation in problem solving approaches.

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[1] Robert M. Gagné, "Human Problem-Solving: Internal and External Events," in B. Kleinmuntz (ed.) *Problem-solving: Research, Method, and Theory* (New York: Wiley, 1966), p. 132.

The risk of a wrong solution to a problem is one factor which usually regulates a learner's choice of strategies. If the situation has a high payoff for a quick solution and a relatively low cost for making an error, a learner will profit most by choosing a strategy that uses the fewest trials. In all problem solving situations, an individual's perception of the reward or the penalty for choosing a particular strategy is critical for successful problem solutions. The learner chooses the strategy which seems to promise the greatest probability of reward and the least chance for punishment in the shortest time. Consequently, in each new problem situation, learners will vary as to the strategy they choose.

Bruner, Goodnow, and Austin (1956) have shown that there are individual differences in the types of strategies learners use to solve problems. The four strategies described by Bruner *et al.* were: (1) *simultaneous scanning* — each "cue" in the problem or concept is tested in order to decide which hypotheses can be retained or eliminated; (2) *successive scanning*—all possible problem hypotheses are tested one at a time; (3) *conservative focusing* — a concept example of the concept or problem solution is used to focus on a plausible answer; and (4) *focus gambling* — more than one aspect (attribute) of the problem is varied at a time.

Gagné (1966) asserted that individual differences originate not only from the various preferred strategies of learners, but also from differences in learners' memory capacities, quantity of information stored in memory, ease of information recall, ability to focus on the distinctive features of a concept, and fluency of generating hypotheses. Thus, the teacher should be sensitive to the factors influencing individual differences rather than expecting all children to solve problems similarly.

As well as recognizing that this issue presents only a small part of the literature on problem solving behavior, the reader should be aware of two additional factors: (1) that inclusion of an abstract does not constitute an endorsement of reported results or applications by the Maryland State Department of Education, and (2) that the studies themselves have definite limitations. In any single experiment, only a limited number of subjects can be run and they are likely to be obtained from a single school, or school system, or undergraduate college course. Across experiments, types of problems, methods of problem presentation and response measures vary. Also, most experiments are conducted in a controlled, laboratory situation. Therefore, generalization from experimental results to specific classroom situations should be done with caution and on a "try out" basis. Additional information or problem solving, and suggestions for implementing research results can be obtained by reading the original sources for the "Abstracts," sources referenced in the bibliography, and consulting publications such as *Psychological Abstracts* which present brief summaries of new research on a monthly basis.

For the convenience of the reader this issue of the "Abstracts" is divided into five sections. The first section treats the general topic of strategies or modes of approach in solving problems, while the second deals with verbal and perceptual processes. In the third section, age-related changes in strategies and conceptual approaches are examined. The last two sections review the influences on problem solving of a number of variables such as intelligence, motivation, anxiety, and sex.

section I

problem solving strategies

Although the identification of problem solving strategies is an important task, it is incompletely understood (Miller, Galanter, and Prebram, 1960). Bruner, Goodnow, and Austin (1956) made a significant contribution to this field when they began to identify patterns in a subject's problem solving responses and the procedures for identifying these patterns. Since the initial research by Bruner and others, further experimentation has revealed various problem solving strategies and numerous factors which influence a subject's choice of a specific strategy. It is evident from an analysis of such studies that subjects differ in choice of problem solving strategies. Therefore, any efforts to individualize instruction should take into account how and why students differ in strategy choices.

In this section, the first study investigated children's use of replacement and nonreplacement strategies. The second study considered the identification of strategies and the function of learning sets in concept attainment. The final two studies investigated the strategies used in problems with positive and negative instances (information).

replacement and nonreplacement strategies in children's problem solving

Purpose: To determine if a nonreplacement strategy produces more effective learning, near transfer, and remote transfer than does a replacement strategy.

Review: In problem solving situations, experimentation has suggested that both children and adults often sample with replacement — that is, they repeat incorrect hypotheses and answers. The investigator hypothesized that a more efficient problem solving procedure (defined as sampling without replacement) is to sample only from those hypotheses or answers which have survived elimination on previous trials. They further hypothesized that such an approach should produce greater learning and transfer even when new concepts replace those used during training.

The subjects were 66 boys and 53 girls representing the entire second grade population of two Los Angeles public elementary schools. All subjects were first given eight familiarization problems. The children were then randomly assigned to one of three experimental groups where they would learn to discover the single concept that related a series of six paired pictures to the model on the screen. The Nonreplacement Group was taught to hang their concept cards on their response boxes and then to place face down any concept card which did not represent the correct basis for matching the two response box pictures with the model picture on the screen. This procedure was to be followed as the pictures were presented until only the correct card was left and verified.

The Replacement Group was taught the procedure described above except that no mention was made of placing eliminated concept cards face down. The Control Group was simply given the concept cards and told to find the one rule for matching. After experimental learning, four post-tests were administered to each group. During testing, the children were given no cues or strategies, but were told the four possibly correct bases for answering the problems.

On each of the four tests (learning with cards, transfer to new instances with cards, transfer to new instances without cards, transfer to new concepts without cards), performance was highest for the Nonreplacement Group, followed by Replacement and Control Groups. On learning with cards, the Nonreplacement and Replacement Groups were not significantly different from each other, but both were significantly higher than the Control Group. On the transfer to new instances with cards, the Nonreplacement Group transferred significantly better than either of the other groups. For the test of transfer to new instances without cards all differences among the three groups were statistically significant. For transfer to new concepts without cards, the Nonreplacement Group was significantly better than either the Replacement Group or the Control Group.

Conclusion: The investigator concluded that ". . . children not only learned to use the strategies, but they could transfer them to problems without the cards or props, even to difficult problems involving transfer to four new concepts. . . . To develop a theory of instruction, data are needed about treatments which produce transfer. The teaching of problem solving strategies to young children is both a way to obtain transfer and to develop a theory of instruction."

Comment: Note that all subjects received the post-experimental tests in the same order. It is quite possible that remote transfer, for example, would have yielded lower scores had it not been preceded by three tests requiring similar concepts. Also, a remote transfer test with cards would have yielded valuable information on the role of cue cards in this process.

Source: Wittrock, M. C. "Replacement and Nonreplacement Strategies in Children's Problem Solving," *Journal of Educational Psychology*, LVIII, No. 2 (1967), 69-74.

strategies and learning set in concept attainment

Purpose: (1) To develop an objective procedure for identifying strategies; and (2) to determine the relationship between strategies and performance.

Review: The literature on concept attainment contains many references to strategies or patterns of response in achieving problem solutions. However, for complex problems most investigators have failed to specify the precise steps by which strategies are classified. In this experiment, six pure strategies (all responses from the same response class) and twelve mixed strategies (responses from two or more response classes) were defined. In addition, the risk or uncertainty associated with each strategy was mathematically determined.

The subjects were 18 males and 18 females selected randomly from a university class. The subject's task was to solve six concept problems, each of which had two relevant dimensions and five irrelevant dimensions. Each dimension had two instances — for example, color was represented by red and green. There were 128 stimulus cards representing all possible combinations of two levels of each of the dimensions. At the beginning of each concept problem, the focus card or positive instance of the concept was pointed out to the subject. A different focus card was designated on each succeeding problem. Subjects were told to discover the correct categorizing rule as soon as possible by choosing cards from the array and checking hypotheses with the experimenter. They were also told the total number of relevant dimensions. The order of problem presentation was counterbalanced across subjects in such a way as to make possible an analysis of problem position and sequence effects. The dependent variables were the number of card choices on each problem and time-to-criterion (time from presentation of focus card to statement by the subject of the correct rule). An analysis of variance was performed on each of these variables. The existence of a practice effect was shown by significant reduction in both time-to-criterion and total-card-choices, across ordinal positions. "As subjects became more practiced on this type of concept attainment task, they became more efficient both in terms of the length of time they spent at the task and the number of cards they selected. This increase in efficiency was interpreted to be evidence of learning set."

Of the 18 possible strategies for obtaining problem solution, subjects generally tended to use the five that minimized risk and maximized information (low risk is associated with high information yield). Subjects were also quite stable in their use of strategies -- i.e., over six problems, the average subject used only two strategies. The direction of change was toward less risk.

Conclusion: The data substantiated the prediction that, as subjects became experienced in concept attainment, they would more frequently use low risk strategies.

Comment: Experiments such as this help to identify and quantify the variables involved in problem solving behavior. If strategies and response classes can be precisely stated, then methods of instruction are much easier to develop.

Source: Byers, J. L. "Strategies and Learning Set in Concept Attainment," *Psychological Reports*, XII (1963), 623-634.

concept identification strategies used for positive and negative instances

Purpose: To account for differences in a subject's ability to use negative and positive instances in terms of a subject's: (1) conclusions about a concept; and (2) report of his reasoning processes.

Review: Thirty subjects from introductory psychology classes were randomly assigned to either a task containing positive instances (information) or one containing negative instances. The tasks required subjects to identify from eight attributes — the letters A through H — the conjunctive concept A, D, E, and G. The letters were either present or absent in an instance (a row).

The positive task contained five positive instances, each marked positive (+), with the first task containing all four of the defining attributes (e.g., A, D, E, and G). The negative task contained the same first positive instance as the positive task and then four negative instances marked negative (—).

The task was presented to subjects one instance at a time with previously presented instances remaining in view.

The strategies of reasoning which subjects used in order to draw conclusions concerning the concept were: (1) the subject's record of his conclusions; and (2) the subject's report of the reasoning he used to solve the task. Subjects were required to state for each attribute (letter) whether it was in the concept (I) or not in the concept (N) or that they didn't know (?). Subject's strategies were inferred from the post-experimental interview and from the "I," "N," and "?" responses.

A preliminary examination of the interviews revealed that strategies were composed of two components — a premise and a conclusion. Premises referred to information used by subjects, while conclusions referred to inferences drawn from that information. The individual subject's statements of premises and conclusions were translated or coded into standard statements and then analyzed for patterns of statements or strategies. Three types of strategies were discovered: (1) formal strategies consisting of correct deductive reasoning; (2) concrete strategies consisting of unintegrative inferences from specific information; and (3) nonprocessing strategies in which the subject did not process information to which he had responded.

Subjects receiving the negative task used correct formal strategies less frequently and incorrect concrete strategies more frequently than positive task subjects.

Conclusion: The investigators concluded that the differences between positive and negative instances arise ". . . from the preferred inferences which subjects make from the most important piece of information in the task, the absence of an attribute from each instance." This inference is a correct one when applied to positive instances, but incorrect for negative instances. Thus, differences in proficiency for positive and negative instances depend upon a subject's ability to use the absent attribute correctly.

Comment: The findings of this study may indicate that subjects need to be trained to use negative and positive instances differentially. Although subjects have preferred strategies and strong tendencies to interpret an absent attribute as if it were not in the concept, training in the correct use of a negative instance and in the use of formal strategies with negative instances may be helpful.

Source: Denny, J. Peter, and Benjafield, John G. "Concept Identification Strategies Used for Positive and Negative Instances," *Psychonomic Science*, XIV, No. 6 (1969), 277-280.

strategy selection and negative instances in concept learning

Purpose: To explore a subject's ability to use negative (nonreinforced) information in concept learning tasks.

Review: In concept learning tasks, the investigators noted that a subject could learn a concept from either nepative or positive information — often called nepative or positive instances. Conventionally, a positive instance was defined as an example of the concept to be learned, whereas, a negative instance had one or more ". . . critical dimensions of the concept absent with no consistent defining attribute except the absence of the correct concept." In this study, however, positive instances were represented by reinforced concepts; and, similarly, negative instances were represented by nonreinforced concepts.

Evidence from earlier experimentation (Bruner, Goodnow, and Austin, 1956) had suggested that humans were either unwilling or unable to effectively use negative information even when its informational value was equivalent to positive information. Braley, on the other hand, hypothesized that subjects may actually use negative information in concept learning tasks not as a negative cue in itself, but in the formation of exclusion strategies. Exclusion strategies or solutions can be classified according to the type of concept to be learned. Generally, concepts are classified as conjunctive, disjunctive, and relational. Conjunctive concepts are those in which each positive instance has the defining property or properties of the concept. In contrast, positive instances in disjunctive concepts have one or the other of the defining properties of the concept, while the positive instances in relational concepts have a common set of relationships. The concept-exclusion strategies were, therefore, conjunctive-exclusion, disjunctive-exclusion, and relational-exclusion.

Three experiments were conducted in which the general procedure consisted of the simultaneous presentation of a positive and negative instance.

Study I required subjects to meet a criterion ". . . either by learning the reinforced concept or by learning the concept represented by the negative instance and then choosing the opposite instance." However, when the reinforced condition was more difficult to learn, the investigator asserted that learning would be more efficient if the easier concept represented by the negative instance were learned and then, "by exclusion," the reinforced concept chosen.

Forty high school students were randomly assigned to four experimental conditions: two conditions of instruction, problem solving directions and concept attainment directions; and two types of concepts — disjunctive and relational.

After the groups were given their respective instructions, all subjects on each trial were simultaneously shown the examples of the disjunctive concept and the relational concept. For one-half of each instruction group, the disjunctive concept was correct; and the relational concept was correct for the other half. If a subject's indicated choice was correct, reinforcement was indicated by the flashing of a light. To meet criterion, twelve successive correct responses were necessary.

An analysis of variance revealed that the relational concept was easier to learn than the disjunctive concept. However, despite the ease of learning the relational concept, subjects did not make use of the relational-exclusion solution to meet criterion.

In *Study II*, 16 males and 24 females were evenly distributed among the same four experimental conditions as in *Study I*. The procedure used in this study was similar to that of *Study I*, except one-half of the subjects were reinforced on a conjunctive concept. The remaining half, however, were reinforced on those instances which didn't have any defining attributes of the concept. Thus subjects in this condition were forced to use an exclusion strategy in order to solve the problem. All subjects in the conjunctive-exclusion group were unable to reach criterion.

Study III was a partial replication of *Study II*, but only the set of problem solving instructions was used. Half of the subjects were again reinforced on the conjunctive concept and the remaining half on those instances devoid of defining attributes. However, for half of each of these two groups, reinforcement occurred for a choice of the correct instance; for the other half, reinforcement indicated an incorrect choice had been made. The results of this experiment constituted a replication of *Study II*. Only two of the 20 exclusion condition subjects met criterion. Both of these subjects were in the correct response condition.

Conclusion: The evidence gathered in this experiment indicated that humans are unable to handle negative information. Neither instructions and conditions of reinforcement, nor types of concept employed had any substantial effects on a subjects' ability to use negative information.

Comment: The finding that very few subjects were able to use an exclusion-strategy effectively (even when this strategy was the most efficient one) may indicate not so much that the use of negative information is impossible, but that this strategy is very low in most subjects' response repertoires. Because the exclusion strategy places a heavy load on a subjects' memory, it is probably only used as a higher level or secondary strategy. Instead of allowing students to proceed on a trial-and-error strategy or some other inefficient strategy, it may be possible through training to teach children to use the exclusion strategy when it appears to be the most effective one. Of course, the greater a subject's memory capacity, the more efficiently he will be able to use an exclusion strategy.

Source: Braley, Loy S. "Strategy Selection and Negative Instances in Concept Learning," *Journal of Educational Psychology*, LIV, No. 3 (1963), 154-159.

section II

the use of verbal cues and mediational processes

As early as 1930, Maier showed that cues can affect problem solving. Even a brief verbal cue such as "Don't be blind," can affect the manner in which an individual attempts to solve a problem. The concept of verbal cueing is not only important in laboratory experimentation but also in the classroom setting. Educators have often been plagued by the problem of trying to determine the type of verbal assistance to give students during learning, retention, and transfer.

Verbal mediation is another important phenomenon to be considered in both laboratory research and in the classroom. Kendler and D'Amato (1955) have shown that verbal mediation is an important process for adults. However, Kendler and Kendler (1959) suggested that very young children learn by a single unit (direct association between physical stimuli and overt responses).

In this section, the first two studies dealt with verbal cueing. The next two studies investigated the mediational processes used by children. The final study reported the effects of language, age, and logical structure on children's problem solving behavior.

verbal cues in concept identification

Purpose: To predict the effectiveness of a general or specific verbal cue upon transfer.

Review: From previous research (Wittrock, 1963), the present investigators asserted that the kind of verbal cues used by teachers to direct problem solving activities can affect learning, retention, and transfer. Based on this theory, it was hypothesized that among subjects who had the relevant associations to make cues meaningful, ". . . the greatest retention and transfer within a class of problems [would] occur when the name for the class (the Class Cue) rather than a more General Cue or a more Specific Cue is given by the experimenter while the subjects solve problems of the same class."

Ninety kindergarten children from a West Los Angeles public school were taught a hierarchy of associations including the words which were later used in the experimental treatments as cues to the problem. Children were given 32 preliminary training sessions (five to ten minutes each) in which they were taught the hierarchy of cue associations. The word "article" (General Cue) was associated with "la," "le" (two Class Cues) each of which was associated with six French nouns (Specific Cues). Each of the 12 French nouns was associated with a picture.

Of the 90 subjects who began the experiment, only 52 successfully completed the preliminary training. Subject loss was due to absence and failure to learn the task. The children were ranked by IQ and assigned by a stratified random method to three experimental treatment groups (General Cue, Class Cue, and Specific Cue), and one control group which was told the name of each picture. All children were shown slides containing three pictures, one at the top and two below. They were required to match (by some basis) one of the two bottom pictures with the one at the top. All groups were given directions which indicated the correct verbal cue to be used.

An analysis of variance revealed that a class verbal cue produces greater transfer to new instances of the same class than does either a more general or a more specific cue.

Conclusion: The investigators concluded that relevant Class Cues rather than specific answers or an abstract cue facilitates a kindergarten child's retention and ability to transfer new concepts. They further suggested that although the children in this experiment already had been taught the common responses ("article," or "la" and "le"), additional verbal cueing was necessary in order for the children to know which attribute of the experimental picture was relevant.

Comment: From the results of this study, it appears that kindergarten children are unable to learn or transfer previous learning when they are asked to use a "discovery approach" aided only by abstract or very specific cues. In order to effectively use a "discovery approach" with young children, teachers will probably need to instruct children first how to use the Class Cues previously associated with correct answers and then to eliminate incorrect alternatives. However, because of the high attrition rate in this study, generalizations must be made with caution.

Source: Wittrock, M. C.; Keislar, Evan R.; and Stern, Carolyn. "Verbal Cues in Concept Identification," *Journal of Educational Psychology*, LV, No. 4 (1964), 195-200.

verbal cues in the transfer of concepts

Purpose: To determine the transfer effects of a general verbal cue, a class cue, and a specific cue.

Review: One-hundred and sixty children (25 second graders and 135 third graders) were brought by groups of ten or fewer to a special classroom for ten sessions of 15 minutes duration. After the first two days of preliminary training and testing, the 160 children were stratified by IQ and randomly assigned to three experimental groups and one control group. The control group was given only the tests. Each day during the four sessions, all experimental subjects were asked to solve six concept problems with four instances (an attribute of the concept to be solved such as color or size). Each concept problem was presented as a sequence of ten-to-fifteen slides. A slide consisted of three pictures, one on the top of the slide and two below. The task required subjects to discover the basis or rule for matching the top picture with one of the two bottom ones and ". . . to use this rule on all remaining slides in the problem sequences." All experimental groups received the same instructions and sequence of slides. The only difference between the experimental treatments received by the three groups was the type of verbal cue each group heard simultaneously with each slide. The cues consisted of: (1) The Specific Cue which was the specific answer for the matching problem; (2) The Class Cue which was the correct concept label for the answer; and (3) The General Cue which was either always the same two concept labels or the statement "some other way."

Three post-tests were administered to subjects two days after the experimental training. Each of these tests presented four new problems to the subjects. The first, a test of training, consisted of problems involving the same concepts and instances as the training items. The second test, involved the same concepts (e.g., color, size), but new instances of the concept (e.g., red, green). The third test involved transfer to new concepts.

Three weeks later, the three post-tests were presented in a different order as measures of retention and transfer.

An analysis of covariance revealed that the Class Cue and the Specific Cue were more effective aids to learning retention, and transfer to new instances than the General Cue. Transfer to a new concept was not significantly affected by the presence of any of the cues.

Conclusion: The Class Cues (named for the concepts) and the Specific Cues ". . . produced the greatest learning and transfer within the previously learned class." The investigators postulated that if children have previously learned to group specific instances (e.g., green or red) into a category (e.g., color), then concepts can be easily induced from the instances. This type of behavior has often been labeled as "discovery behavior." However, the investigators noted that the type of "discovery behavior" occurring from the deduction of a concept from General Cues, did not occur as readily as the inductive discovery.

Comment: The results of the study indicate that a "General Cue" produces little discovery behavior in young children. Therefore, if a teacher wants to employ a "discovery approach" in order to teach a new concept to young children, the "inductive discovery method" utilizing Class Cues or Specific Cues may be best.

Source: Wittrock, M. C., and Keislar, Evan K. "Verbal Cues in the Transfer of Concepts," *Journal of Educational Psychology*, LVI, No. 1 (1965), 16-21.

perceptual versus verbal mediation in the concept learning of children

Purpose: To determine whether verbal mediation can be effectively used by young children in concept learning.

Review: The investigator noted that theorists of cognitive development such as Piaget and Werner have hypothesized that the cognitive processes of young children are characterized by their concrete and sensorimotor nature. In order to investigate this proposition, the present experimenter developed the following hypotheses:

1. "When perceptual field conditions emphasize one of two or more dimensions which are relevant in a prior learning task, learning in a subsequent task . . . will be (a) facilitated when the previously emphasized dimension maintains its relevance but the correct value shifts, and (b) impeded when the previously emphasized dimension is irrelevant in the second problem."
2. "The effects predicted in hypothesis 1 will be more pronounced for younger children than older children."
3. "If a verbal basis for establishing a mediating response to one dimension and a perceptual basis for developing a mediating response to another dimension are simultaneously presented, and both dimensions are relevant to the learning situation then older children's mediation will be more influenced by the verbal aspect and younger children's by the perceptual."

Fifty nursery-school children with a mean age of 3.8 years and 75 second-graders with a mean age of 8.0 years participated in this study. The measured intelligence of both groups of children was average; and, the investigator indicated that the children were representative of the upper-middle-class.

The children were given two discrimination tasks which required them to "feed a clown" by placing the relevant object, or the object which would be rewarded, in the clown's mouth. The first task entailed the presentation of a large black cylinder (rewarded) paired with a small white one (not rewarded). Randomly presented on the second task, were either (1) the same pairs with reinforcement patterns reversed or (2) a large white cylinder (not rewarded) and a small black one (rewarded). In effect, the first task allowed either of two mediating responses to develop (e.g., size, brightness) whereas the second task allowed only the size dimension to remain relevant.

In order to assess the effects of perceptual or verbal mediation the following treatments were administered to the children:

I. *Perceptual treatment.* — Cylinders were arranged according to size or brightness. When the size arrangement was used, all cylinders of the same height were placed on the side of a tray. Objects were randomly distributed with respect to brightness. When the brightness arrangement was used, the black cylinders were placed on a black background and the white ones on a white background, size being randomly distributed.

II. *Perceptual and Verbal Conflict Treatments.* — In the conflict conditions for each perceptual arrangement, a verbal basis for mediation to the opposite dimension was provided by instructing subjects to use verbal labels. For example, while the perceptual arrangement stressed size, the subjects were instructed to label the objects according to their brightness. Likewise, while the object arrangement involved brightness grouping, subjects were instructed to tell the experimenter if the correct response was a large or small cylinder.

An analysis of variance revealed that positive transfer resulted when the perceptual arrangement emphasized a relevant dimension, and negative transfer resulted when the dimension was irrelevant for the conceptual task. This latter effect was stronger for the younger children. In the conflict condition when the perceptual arrangement was irrelevant and the verbal response relevant, older children showed positive transfer and younger children negative transfer.

Conclusion: The investigator concluded that ". . . by arranging objects in a certain pattern, mediational effects could be achieved in young children which are similar to those obtained by verbal means in older children." The investigator also believed that perceptual responses are theoretical constructs and thus can interact between external stimuli and an overt response, in much the same way as the theoretical construct of the implicit verbal response used by older children and adults.

Comment: Teachers should be aware that various types of mediating processes may be used by learners for different conceptual tasks at various stages of development. Lessons can be designed in order to enhance certain types of mediating processes which may facilitate the learning of individual children.

Source: McConnell, Owen L. "Perceptual versus Verbal Mediation in the Concept Learning of Children," *Child Development*, XXXV (1964), 1373-1383.

reversal and nonreversal shifts in kindergarten children

Purpose: To determine whether kindergarten children would respond to a discrimination task ". . . in a manner consistent with a single unit or a mediational S-R theory of discrimination learning."

Review: One-hundred and twenty-two kindergarten children (53 girls and 69 boys) were presented with a discrimination task which required the children to learn an initial discrimination between stimuli that differed on two dimensions by having only one of the dimensions relevant or rewarded. After the criterion was reached, a second discrimination task was presented to the children. For the reversal shift, the same dimension remained relevant for both tasks, but the reward patterns were reversed. For the nonreversal shift, the previously irrelevant dimension became relevant.

The single-unit S-R theory assumed a direct association between physical stimuli and overt responses. This theory predicted that a task which required a reversal shift (i.e., making a response opposite to that previously learned) would result in slower learning than a nonreversal shift. This theory has been corroborated with "inarticulated organisms" and very young children. Kendler and D'Amato (1955) predicted, however, that because adult humans use verbal responses to mediate between the external stimuli and overt responses, more rapid learning should occur with reversal shift. The investigators reasoned that ". . . at the completion of the learning of the first concept, the symbolic cues appropriate to the second concept were available to subjects in the reversal shift groups." Their prediction was confirmed with adult subjects.

All subjects were randomly assigned to the experimental groups (reversal and nonreversal) and a control group. The initial discrimination task for the experimental group required subjects to discriminate between four metal tumblers that varied both in height and brightness. Forty subjects learned to respond to brightness. For half, black was positive; for the other half, white was positive. Another group of forty subjects learned to respond to height, half to tall and half to small. The control group subjects were presented with a shape discrimination task. For half, a diamond figure was positive; for the other, half a circle figure was positive. One of each shape had two round dots on its top. The dots were irrelevant cues.

The second discrimination task was presented immediately after the criterion for the first task was reached. There was no change in instructions or interruption in the procedure. Each of the experimental groups was divided equally into a reversal and a nonreversal group. The reversal group subjects were required to respond to the stimulus feature which had previously been nonreinforced. The nonreversal subjects were required to respond to the stimulus feature which had received approximately the same number of reinforcements as nonreinforcements.

For the control group, half were presented with only tall cylinders or only short cylinders. One-quarter were rewarded for choosing black and the other for choosing short. The other half were presented with a combination of tall and short cylinders. One-quarter were rewarded for tall and the other for short.

A factorial analysis of variance revealed no significant differences in performance. Neither the single-unit S-R theory prediction nor the mediational S-R theory prediction was confirmed.

When subjects were divided into fast and slow learners on the basis of the number of trials needed to reach criterion on the training discrimination task, the difference between fast and slow learners was significant. Fast learners performed in a manner consistent with a mediational S-R theory — that is the reversal shift task was more easily learned than the nonreversal shift.

Conclusion: On the basis of the analysis of the responses of the total group, and the fast and slow learners ". . . it seems reasonable to conclude that these [kindergarten] children, taken as a group, were in the process of developing mediating responses relevant to this task and that some were further along than others."

Comment: It appears that the primary grades are a transition period in the development of the ability to use verbal mediation which is so important for complex problem solving. The primary teacher should be particularly sensitive to the fact that some children have made the transition while others have not.

Source: Kendler, Tracy S. and Kendler, Howard H. "Reversal and Nonreversal Shifts in Kindergarten Children," *Journal of Experimental Psychology,* LVIII, No. 1 (1959), 56-60.

some effects of logical structure, language, and age in problem solving in children

Purpose: To ". . . analyze the influence of logical structure and language in thinking processes and their changes with age."

Review: The investigators postulated that the difficulty level of a problem depends on two independent components: (1) the logical structure of the problem (i.e., set of established relationships inherent in the problem); and (2) the language used to express the problem (e.g., words, concrete objects, or special symbols). The investigators further postulated that an analysis of a subject's thinking process could be made by evaluating the sequence of questions he used to solve a problem. However, because of the problems of experimental control involved when a subject is free to generate questions, subjects were presented with a set of possible questions and chose those that they considered necessary to solve a problem. The investigators assumed that "asking" a question and "choosing" a question were equivalent processes. Thus, the number, the order, and the type of questions chosen were recorded as a subject's strategy for problem solving.

The total sample of 120 subjects used in this study consisted of four equal subgroups of children aged seven, nine, eleven, and thirteen. To avoid heterogeneity, all subjects were chosen from the same socioeconomic background and were academically above average according to teacher ratings.

Six different problems were used in this study. Problems A, B, and C required subjects to determine the number of objects hidden under a portion of a square; problems D, E and E-1 were verbal problems. The best strategy for solving each problem was defined by the investigators in terms of the logical structure of the problem and the set of possible questions presented with the problem. The strategies used by each subject were analyzed using the following approaches: (1) the number of questions asked; (2) the pulling-out method which was a comparison between the subject's strategy and the logically defined "ideal" strategy; and (3) an analysis of the right and wrong answers to the problems.

A simple analysis of variance on the pulling-out scores for all subgroups on the six problems showed a significant difference among age groups in the ability to use ideal strategies. A two-factor analysis of variance with repeated measures as one factor was performed in order to evaluate the influence of age and language on performance in problems of identical logical structure. The results of the analysis revealed an interaction between age and language in problems B and E. Further analyses demonstrated that: (1) there is an increase of agreement among subjects' strategy with age; (2) there is an interaction between language and the logical structure of a problem; and (3) logical structures and language are not experimentally independent variables.

Conclusion: The ability to solve all problems efficiently generally improves with age. The relationship between age and language is not clearly understood, for age-language interactions appeared only in certain problems; also there is no apparent age-language interaction until age 13. The investigators asserted that for increasingly more complex problems the use of language structures which were handled by a subject at an early age (i.e., seven) with simpler problems became paradoxically more difficult with increased age. Furthermore, the investigators hypothesized that as an individual's ability to use language (e.g., words, concrete objects, and special symbols) improves, he is able to solve problems which he had been unable to solve up to that point. Prerequisite to the developmental acquisition of new languages, one's conceptual logical framework must have reached a given level of complexity.

Comment: The complex nature of language should be considered by teachers when problem solving situations are presented to children. The use of vocabulary in word problems such as in mathematics should be carefully analyzed and evaluated. It is important for a teacher to keep in mind that a child's inability to solve a problem may be caused by the complexity of the language structure and not the logical structure of the problem. Other modes of presentation besides the purely abstract verbal mode (e.g., demonstrations) may help children solve problems more efficiently. Also, certain problems may only be solved when children develop more sophisticated conceptual logical framework.

Source: Rimoldi, H. J. A.; Aghi, M.; and Burger, G. "Some Effects of Logical Structure, Language, and Age in Problem Solving in Children," *The Journal of Genetic Psychology,* CXII (1968), 127-143.

section III

developmental changes in conceptual behavior

Cognitive development in children has been shown by various investigators to progress in an orderly fashion from primitive, concrete operations to progressively more abstract ones. Research also suggests that there are concomitant developmental changes in problem solving strategies. Weir postulated that the major developmental differences in problem solving result from "Differential growth of the ability to generate hypotheses and employ strategies and the ability to process the information Ss [subjects] gain from their own responding."[1]

In this section all of the studies analyze the developmental changes occurring in problem solving.

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[1] Morton W. Weir, "Developmental Changes in Problem-Solving Strategies," *Psychological Review*, LXXI, No. 6 (1964), pp. 437-490.

information-seeking strategies in cognitive development

Purpose: To investigate whether young children can "impose order on a perceptually disordered environment."

Review: Forty-eight Iowan children were selected from grades kindergarten, one, and two to participate in the experiment. All the children were rated above average in mental ability by their teachers.

One-half of the children at each age were shown an Ordered Array of 24 line drawings of familiar objects. The other half were shown a Random Array of the same drawings. The drawings consisted of four different animals and four different toys with each animal and each toy being drawn in red, yellow, and blue. In the Ordered Array a column consisted of all the drawings of the same color, and a row consisted of the three pictures of each animal or each toy. The position of the drawings in the Random Array were determined randomly.

Prior to the beginning of the first task or "game" the experimenter instructed each subject to guess the drawing that the experimenter had in mind. A subject could ask any question about the drawings as long as the question could be answered by the experimenter with a "yes" or "no." Each child played four games with half of the children playing Games one and two and the other half playing Games three and four. The rules for Games three and four allowed the alternatives previously guessed by a child to be removed from the array so that the child did not have to remember which drawings still needed to be checked. However, the rules for Games one and two did not allow eliminated alternatives to be removed.

After the children played the four games, they were required to show their "ability to recognize the information value of particular questions." Ten pairs of questions were presented to each child, and he was instructed to choose the question he would rather ask at the beginning of a game like those he had previously played. For each of the more valuable questions chosen, the child's score increased by one; for each of the less valuable questions chosen, the child's score decreased by one.

The strategy-seeking behavior used by each child during the games was characterized by various constraints or limitations. The strategies were classified as follows:

1. Constraint I . . . the child used the toy-animal dimension in combination with other appropriate constraints . . .
2. Constraint II . . . questions involved constraints but not the toy-animal dimension . . .
3. Guessing each question was a direct test of only one alternative . . .

An analysis of variance revealed that guessing was the strategy most used by six-year-olds when they were shown the Random Array. For all other age groups using either an Ordered Array or a Random Array, the dominant strategy used was Constraint II. In addition, it was found that the children using the Ordered Array tended to choose fewer valuable informational questions.

Conclusion: The investigators suggested that the information-seeking strategy of the young child is hindered by his inability "to impose order on a perceptually disordered environment [i.e., the Random Array]." The study further suggested that: (1) children are less able to recognize efficient strategies than to generate them; and (2) establishing constraints in the Random Array aided the recognition of informative questions.

Comment: From the finding of this study it appears that children need training in eliminating alternative strategies when many strategies for solving a problem are presented. Such training would appear to be critical in subjects like mathematics when a number of possible strategies have been presented to children for solving any single given problem. Finally, the extent to which age confounds the problem of eliminating alternative strategies has yet to be determined.

Source: Van Horn, Roger and Barty, Wayne, H. "Information Seeking Strategies in Cognitive Development," *Psychonomic Science*, XI, No. 10 (1968), 341-342.

developmental changes in problem solving strategies

Purpose: To analyze the performance of subjects at a number of age levels on a problem solving task.

Review: Although much literature on problem solving and related topics has been published, the investigator pointed out that only a few researchers have attempted systematic analysis of developmental changes. He has proposed to trace developmental changes in three-choice probability learning from age three to adulthood.

The subjects were 290 children and college students ranging in age from three to twenty years. Mean ages were 3.6, 5.5, 7.0, 9.2, 10.8, 14.8, and 18.0 years.

The subjects were given a three-choice probability learning task where choices of one of the alternatives were partially reinforced and choices of the other two were never reinforced. For one experimental group, the partially reinforced or correct choice was randomly reinforced with a marble on 33 percent of the trials, while for the second, reinforcement occurred on 66 percent of the trials. All subjects were given 80 trials.

Since the number of subjects in each age group was disproportional for the 33 percent and 66 percent conditions, separate analyses were performed. Dependent variables included terminal level of response, patterns of response, and performance as a function of the preceding response. Terminal level of responding was higher for the 66 percent group. The relationship between age and response was U-shaped and differed significantly across age for both conditions. Age and simple patterns of response had an inverted U relationship to each other. Younger subjects showed a more rapid rise to terminal level of response than did older subjects.

Younger subjects also tended to repeat their previous response whether it was correct or incorrect. The 7-, 9-, 11-, and 15-year olds, however, often tried out a win-shift lose-shift strategy (i.e., after a correct response, the subject responds to a previously incorrect alternative).

Conclusion: Children in the 9 to 12 age range appeared to use patterned response strategies (i.e., repetition of certain response patterns such as left-right) similar to those used by older children and adults. But, unlike the older subjects, the 9- to 11-year olds did not abandon their patterned response strategies in response to low reinforcement. Weir theorized that 9- to 11-year olds may be unable to recall their pattern of previous responding plus the actual event outcomes. Thus, their hypothesis testing is inefficient. Young children did not generate stereotyped response patterns and, therefore, did not face the same hypothesis testing situation.

Comment: In the author's view, it is obvious that ". . . not all subjects within each of the age groups went about solving this problem [three-choice probability task] in the same fashion. However, further research which would include such individual difference variables as intelligence and certain measures of parent-child interaction should make the prediction of individual performance in this task possible."

Source: Weir, Morton W. "Developmental Changes in Problem-Solving Strategies," *Psychological Review*, LXXI (1964), 473-490.

age and memory as factors in problem solving

Purpose: To assess and isolate the effect of memory on the problem solving behavior of children and adults through two experiments.

Experiment I

Review: Previous research has indicated that memory plays an important role in the process of concept identification. If this result applies to problem solving in general, then the investigator hypothesized that the developmental changes which he reported earlier (See, for example, "Developmental Changes in Problem-Solving Strategies," by Weir abstracted in this issue) are related to memory differences at the various age levels.

Subjects for the experiment were 34 six-year-olds, 40 nine-year-olds, and 40 college students. All subjects were given 120 trials in a three choice probability learning task where one alternative was partially reinforced (random with restrictions on 66 percent of the trials) and the remaining two were never reinforced. Half of the subjects at each age were run in the usual fashion, and the remainder were provided with memory boards which allowed them to keep a trial-by-trial record of event outcomes.

The mean number of choices of the partially reinforced alternative (termed correct choices) over the whole task was highest for the adult group. The nine- and six-year-olds had similar means indicating that the significant age effect was due to a child-adult difference. Over trials, all groups significantly increased their frequency of correct responses. At the adult level, responding was not affected by the memory board. However, the nine-year-olds in the memory condition performed significantly better than those in the nonmemory condition, while for the six-year-olds the outcome was reversed. The investigator noted that the younger children didn't seem to understand the relationship between the memory board and the probability learning task, and hypothesized that the board provided them with a seemingly irrelevant and disruptive task.

Experiment II

Review: If the memory board served only to show that just one alternative was reinforced, then the same information could be conveyed by placing a delivery hole and collecting box beneath each response button on the three-choice apparatus (in Experiment I, the apparatus used had only a single, centered delivery hole and collecting box).

In this experiment, 34 five-year-olds, 40 nine-year-olds, and 30 college students served as subjects. Half of each age group were run on the three-box apparatus and half on the one-box apparatus.

Effects due to age and trials were significant, but neither the effect associated with the number of delivery boxes nor any of its interactions were significant. Further analyses of the data from both experiments showed that nine-year-olds and younger children tended to repeat ineffective response patterns or strategies with the exception of the nine-year-old memory-aid group whose responses resembled adult behavior. Adults under all conditions tried out patterned strategies, but soon abandoned them in the face of inconsistent reinforcement.

Conclusion: The investigator concluded that developmental changes in problem solving are at least partially a function of memory. The memory board disrupted the performance of six-year-olds, improved the performance of nine-year-olds and had no effect on adults, while the supposedly similar information provided by the three-box condition had no effect on any group.

Comment: Thus, from the results of these experiments, it is possible that a visual representation of unsatisfactory alternative responses to a problem may be helpful for some students in problem solving situations. Both developmental factors and the method of presenting information must be carefully considered if memory aids are to be effective.

Source: Weir, M. W. "Age and Memory as Factors in Problem Solving," *Journal of Experimental Psychology*, LXXIII, No. 1 (1967), 78-84.

development of logical problem solving strategies

Purpose: To examine ". . . the development of logical thinking in a problem solving task deliberately designed to (a) be relatively content free and (b) provide objective quantitative measures of the quality of Ss [subjects] performance."

Review: Ninetv-six subjects between the ages of nine and sixteen were assigned on the basis of the *California Mental Maturity Scale (CMMS)* to either a "normal" or a "bright" intelligence group for each age in the range of the chronological years. After four or five practice trials, subjects were given a series of eight problems each with a different answer sheet. The answer sheet contained eight patterns, each composed of eight binary elements (black or white circles). The answer sheet was placed behind a problem board in which one of the patterns was concealed under movable shutters. The subject's task was to determine the concealed pattern by uncovering as few of the elements (circles) as possible.

The total information required to identify one of the eight patterns was measured in terms of uncertainty. For each problem, a subject's "strategy score" — actual information-gathering behavior — was computed in terms of the ". . . mean expected informational outcome of a series of shutter openings." On a "safe move" the expected informational outcome of each move equalled one bit of information, whereas on a "gamble" each move had the possibility of either solving the problem or providing less information than the "safe move." Each answer sheet was constructed so that half of the first available moves were "safe moves" and the remaining half were "gambles." All "gambles" would "pay off" on a pattern which was never concealed in the board; ". . . thus, gambling would never be successful on any problem." Upon the completion of the last problem, the Kagan *Conceptual Style Test (CST)* was administered.

A plot of the strategy scores as a function of mental age yielded a curve which shows: (1) random behavior for the nine-year-olds of normal IQ; and (2) increased improvement in performance with age. A further analysis showed that older subjects were adopting a ". . . consistent safe strategy."

An analysis of the group learning curves indicated that improvement cannot be explained in ". . . terms of differential learning rate."

Conclusion: The investigators concluded that the increase in logical information-gathering strategy evidenced with increasing mental age was not due to differential learning rates, but rather to the increasing number of subjects who developed and used a logical strategy. It was further suggested that, for individual subjects, ". . . development of a logical strategy may proceed in an all-or-none fashion, possibly at more than one level of abstraction." That is, once the information gathering is brought under the control of a rule, optimal strategy develops quickly.

Comment: From the results of this study, it appears that the consistent use of a logical strategy appears after a child is able to formulate a rule. Younger children have difficulty producing logical strategies, for their behavior is largely under the control of detailed environmental stimuli. They are guided by the consequences of their actions and therefore *their* problem solving strategy is random.

Source: Neimark, Edith D., and Lewis, Nan. "The Development of Logical Problem-Solving Strategies," *Child Development*, (1967), 38(1), 107-117.

development of hypothesis behavior in human concept identification

Purpose: To study developmental changes in hypotheses (H) testing.

Review: Ingalls and Dickerson noted that H testing is an important component in solving concept-identification problems. They reviewed three theoretical positions which have been proposed to account for H-testing behavior. One theory involved sampling without replacement, where an incorrect H is returned to the H pool and can be used again on later trials of the problem. Where this approach is least efficient, the number of H's available to the subject is never reduced. The second involved sampling without replacement, where incorrect H's are eliminated from further consideration. When this approach is carried through without error, it is known as perfect focusing. The third, known as "local consistency," was intermediate to the two described above. It was assumed that, after an error, subjects resample only from among those H's that are not eliminated logically by the outcome of the error trial.

A partial feedback procedure developed by Levine (1966) was used to test these three theoretical positions. The procedure involved the presentation of two types of trials; on outcome trials the subject was told whether his choice was correct or incorrect, while on non-outcome or blank trials, the subject was told nothing following his choice. Each outcome trial was followed by four blank trials.

Initially, there were 40 public school students from grades five, 40 from eight, and 40 from ten along with 40 college students. Subjects were given extensive pretraining on cue-selection problems, and three subjects each from grades five, eight, and ten were eliminated from the experiment because of pretraining failures. For the experiment, each subject was presented with a series of 16 cue-selection problems with 16 trials in each problem. Feedback was given only on every fourth trial. The stimuli were presented in pairs on cards and differed along four dimensions (size, color, shape, and position) with two instances of each.

The results indicated that subjects at each of the age levels solved cue-selection problems by H testing and that performance improved across age. Subjects tended to retain a correct H on blank trials, since the probability of changing H's was small for all age groups. Subjects also tended to select a new H from the pool of possible H's following an error, and this tendency significantly increased across age.

Conclusion: The subjects at each of the age levels demonstrated focusing behavior rather than just simple nonreplacement or local consistency. Even the youngest subjects used a fairly large part of the information made available by the feedback trials.

Comment: The performances of the fifth-grade subjects were surprisingly high in view of some previous research which has indicated rather weak H testing in younger children. However, as the investigators noted, subjects in this experiment were given an unusually large amount of experimental pretraining. It may be possible, therefore, to improve an intermediate grade child's H-testing ability by training children to use efficient strategies.

Source: Ingalls, Robert P., and Dickerson, Donald J. "Development of Hypothesis Behavior in Human Concept Identification," *Developmental Psychology*, I (1969), 707-716.

development of formal reasoning in concept formation problems

Purpose: To test children's understanding of simple causal relations.

Review: The investigator studied the development of formal reasoning in children by using puzzles similar to those used previously by her and by other researchers in concept formation experiments with adults.

The subjects were 300 children, 25 boys and 25 girls from the first, third, fifth, seventh, ninth, and eleventh grades of the Concord Public Schools. Children were run in small groups. They were seated in front of the experimental apparatus (puzzle box) and told that they would be given a set of puzzles to solve. They received two sample problems, and instructions to draw the answer to each problem on a new page of their response booklet.

The puzzle box contained a cut-out board and a set of shaped blocks that fit the eight different holes in the board. Each block was of a familiar shape (e.g., triangle) and was black on one side, white on the other.

The "puzzles" were actually concept formation problems involving eight shapes and two colors. Each concept was defined in two instances, and each instance could be positive or negative. Positive instances were identified by a flashing light and a buzzer on the puzzle box, negative instances by no signals from the puzzle box. For example, if the first instance were a black triangle and a white circle accompanied by light and buzzer, then the concept was either black triangle or white circle. If the first instance were the same shapes with light and buzzer omitted, then the concept was either white triangle or black circle. The second instance, which could also be positive or negative, always allowed the problem to be solved with a single answer (e.g., black circle) which the subjects drew in their response booklets. There were thus four possible sequences which could lead to a correct concept: positive instance followed by positive instance (+ +), negative followed by negative (— —), positive followed by negative (+ —), and negative followed by positive (— +). The first two sequences exemplified the method of agreement, and the second two, the method of difference in Mill's methods of inductive reasoning.

There were a total of 24 problems, six problems each of the four types enumerated above, and each subject went through the problems twice. Therefore, the highest possible total score was 48, and the highest score by type of problem was 12. Overall, the mean number of correct scores increased steadily from the first to the seventh grade and then leveled off. The order of difficulty for the sequences was identical to that found in a previous study with adults: (— +) sequences were easiest, (+ +) and (+ —) sequences were of intermediate difficulty, and (— —) were hardest. Children in the first grade scored below chance on the (— —) problems which suggested that the problems were misleading as well as difficult for them. Performance improved across grade levels, reaching approximately 75 percent at the eleventh grade. On the easiest problems, (— +), first graders did over half the problems correctly.

Conclusion: The ability to carry out a sequence of intellectual steps increased with age. The type of sequence involved in the problem affected the accuracy of the younger child much more than that of the older child.

Comment: The younger child has presumably been in fewer situations which require formal reasoning than the older child. If his performance is a function of both ability and experience, then training should improve the accuracy of the younger child.

Source: Huttenlocker, Janellen. "Development of Formal Reasoning on Concept Formation Problems," *Child Development*, XXXV (1964), 1233-1242.

section IV

cognitive and personality factors in problem solving

Without question, the activity which investigators have defined as problem solving behavior is determined and influenced by a variety of factors. Two clusters of factors which have received considerable attention from investigators can be characterized as the cognitive variables and the personality variables. Both the cognitive variables (such as intelligence) and the personality variables (such as achievement motivation creativity, level of defensiveness, and level of anxiety) have been shown to be related to the effectiveness of an individual's problem solving behavior.

In this section, the first two studies investigated the relationships of intelligence and achievement to problem solving ability. The third study considered the influence of achievement motivation on problem solving effectiveness. In the fourth study, the function of creativity was examined. In the fifth study, conformity pressures and the effects on logical problem solving were reported. The final two studies found that anxiety can be detrimental to problem solving effectiveness.

behaviors during problem solving among children of low, average, and high intelligence

Purpose: To ascertain possible differences among the three intelligence level groups in efficiency of method, persistence, and mode of attack in solving arithmetic problems.

Review: Low intelligence was defined as an IQ score on the *Wechsler Intelligence Scale For Children* of 55-80, average intelligence as 90-110, and high intelligence as 120-146. There were 40 children (20 boys and 20 girls) in the low group obtained from 14 special classes for educable mentally retarded children in two large public school systems. Children who had additional handicaps or definite organic symptoms of retardation (e.g., mongolism) were excluded. The average and high groups each contained 20 fifth-grade girls and 20 fifth-grade boys chosen from the same school systems. The mean age for each IQ group was 131 months.

The 29 arithmetic problems used in the study were graded in difficulty by IQ groupings on the basis of extensive pretesting. The easiest problem for the low IQ child was to make 7¢ with three coins. The most difficult problem for the high IQ child was to make $14.53 with 16 bills and coins.

Before a child participated in the study, he was given a survey test on our monetary system, related vocabulary, and arithmetic skills. Each child solved only one problem unless the solution was obtained in under three minutes. If this occurred, a second, more difficult problem was assigned. The dependent variables were: (1) timing of problem solution in seconds; (2) manipulating of coins or figures with pencil and paper; (3) engaging in any nontask activities (which resulted in the experimenter encouraging the child to continue working and was defined as a measure of nonpersistence); (4) verifying the solution by checking the number of coins and/or amount of money; (5) offering incorrect solutions; and (6) using a random (no apparent plan of attack), logical or combination approach to the solution.

Efficiency of method was defined as the ratio of moves actually made to the minimum number of moves required. The high IQ children were superior to the low in efficiency of method, but great variability within each IQ group was also observed, e.g., the ratio varied from .10 to .80 in the high group.

Time to problem solution did not vary significantly among IQ groups indicating that problems were appropriately graded in difficulty. In discovering and correcting mistakes independently, verifying solutions, and using a logical approach, the high IQ children performed significantly better than the average children; the average children performed significantly better than the low. On measures of nonpersistence, offering an incorrect solution, and using a random approach the order was reversed with the low IQ children scoring highest on each variable.

Conclusion: Children of low, average, and high intelligence were found to vary significantly in their approaches to solving arithmetic problems which involved producing a specific amount of money with a given number of coins. The authors noted that even the high IQ children tended to verify only the amount or the number of coins on the first attempt at solution. They suggested that ". . . if these processes can be learned, more specific instruction in school devoted to helping children acquire processes, rather than solutions, would be helpful."

Comment: Specific generalizations from this experiment should be made with some caution as (1) only children of fifth-grade age were included, (2) the method of sampling low IQ children probably misrepresents the typical classroom for retarded children, and (3) the characteristics of the school systems from which the children came were not given. However, the investigators' suggestion that the school should teach processes rather than specific subject matter is apparently being used successfully in the American Association for the Advancement of Science process-approach program. Processes such as classification are emphasized through kindergarten to grade six rather than specific topics.

Source: Klausmeier, Herbert J., and Loughlin, Leo J. "Behaviors During Problem Solving Among Children of Low, Average, and High Intelligence," *Journal of Educational Psychology*, LII (1961), 148-152.

the relation of achievement in problem solving to rate and kind of hypotheses produced

Purpose: To determine if problem solving achievement was related to the rate and types of hypotheses produced.

Review: The investigators noted that successful problem solving requires the individual to formulate ideas or hypotheses about a problem's solution. Sargent (1940) had suggested that both the type and the rate of hypotheses production may be important components of problem solving. To test his proposal, classes of hypotheses used on timed anagram problems were compared with achievement on timed spatial problems.

Each of 32 male undergraduates participated in two individual sessions — six spatial problems were administered in the first session and six anagram problems in the second. There was a seven-minute time limit for each problem, and the instructions emphasized that *all* incorrect hypotheses or false starts should be written down. Hypotheses could be letters or words for the anagram problems and drawings for the spatial problems. If a subject offered an incorrect hypothesis as a solution, he was encouraged to keep working until the time limit expired.

The mean number of problems solved was 1.95 for spatial (six subjects solved no spatial problems) and 3.46 for anagram. Problem difficulty was partially attributed to the time limit imposed. For each type of problem, scores above the median were classified as high achievement, those below as low achievement. Subjects' hypotheses records on the anagram problems were then categorized as either predominantly whole word hypotheses or predominantly letter-combination hypotheses. Exact probability tests indicated that high achievement on either spatial or verbal problems was related to the use of letter-combination hypotheses. "Restructuring in terms of experience with verbal material — searching for combinations such as 'un', 'less', 'ch', or 'th', or finding larger sub-parts like the flower of cauliflower — tends to reduce the uncertainty associated with the anagram."

Exact probability tests were also performed on rate of hypotheses production and achievement on spatial or verbal, or both types of problem combined. The results of the three tests were not statistically significant.

Conclusion: "Anagram hypotheses are readily separated into whole-word and letter-combination hypotheses. The latter tend to be used by subjects who are superior on either anagram or spatial problems, suggesting that ability to select the more effective hypothesis class is a determiner of achievement in problem solving."

Comment: The anagrams used in this experiment were extremely difficult. With easier anagrams where verbal cues are apparent, the whole-word approach might be the more effective strategy. Therefore, children should not be forced to employ only one type of strategy when solving problems, but trained to choose the strategy most appropriate for a problem's solution. In this experiment, all subjects received the spatial problems first, then the anagram problems, and no explanation was offered for the lack of counter-balancing. Also, both sets of problems were supposed to be at the 50 percent level of difficulty. Do the higher anagram scores reflect transfer effects? Producing explicit hypotheses at each step of problem solution is presumably an unfamiliar task for most individuals. Expressing these hypotheses as drawings is presumably even more unfamiliar. Would practice on verbal problems produce positive transfer to spatial problems?

Source: Rhine, R. J. "The Relation of Achievement in Problem Solving to Rate and Kind of Hypotheses Produced," *Journal of Experimental Psychology*, LVII (1959), 253-256.

the relation of achievement motivation to problem solving effectiveness

Purpose: To determine if achievement motivation is related to an individual's problem solving effectiveness and to the length of time spent on the problem.

Review: *The Test of Insight,* a projective test designed to measure achievement motivation, was administered to 100 airmen undergoing basic training at Lackland Air Force Base. All subjects had *Armed Forces Qualification Test* scores in the top 11 percent of the airmen population.

In groups of ten, subjects were given an orientation to the problem solving task and told ". . . that good performance could be considered relevant to achievement goals." After completing *The Test of Insight,* each subject was individually presented with the problem solving task. The subject was shown an apparatus consisting of a panel of lights and switches on a board. Some lights were controlled by one switch, some by two or three. Each subject was given a practice period in which he could discover which switches controlled which light. The problem was to determine which switches needed to be "up" in order to have the greatest number of lights on. However, a subject could not manipulate the switches until he had solved the problem mentally, written the answer on paper, and finally demonstrated the answer on the board. After the subject showed that he understood the problem, he was permitted to submit as many answers to the experimenter as he wished within a 35-minute time limit.

The analyses were based on the responses of 92 subjects, for two failed to follow the instructions and six solved the problem by chance. After dichotomizing the distribution of motivation scores at the median, a chi-square analysis revealed that ". . . individuals with high achievement motivation are more likely to succeed in solving a problem that is related to achievement goals than are individuals with low achievement motivation." High achievement motivated subjects also worked longer on the given problem than low achievement motivated subjects. For the high motivation group — even with the restricted range of intelligence test scores — the correlation between intelligence test scores and problem success was significantly higher than the correlation calculated on the low motivation group. In contrast, a significantly higher correlation between motivation scores and problem solution was obtained by the low motivation group.

Conclusion: "The results showed that subjects with high achievement motivation were more likely to reach a solution [to a problem] than those with low motivation." The relation obtained between achievement motivation and time worked, the investigators asserted, did not simply mean that highly motivated subjects worked long enough to solve the problem. The mean solution time for high and low subjects was not significantly different. However, highly motivated subjects continued to work on the problem even after the problem was solved giving variations of the correct solutions. The investigators postulated that the difference found between the correlations for motivation scores and problem solution was apparently due to some intrinsic motivation for the task and thus only moderately intense achievement motivation was necessary for optimum performance.

Comment: Because achievement oriented students will be differentially motivated by tasks and subject areas, a teacher should not always expect students who possess high achievement motivation to function at an optimum level of performance. Teachers should further keep in mind that in order to reach an ideal level of performance, a less interesting task may require a higher level of achievement motivation, just as a more interesting task may require a lower one. In some cases, high achievement motivation may interfere with learning because of anxiety. (See, for example, "Difficult Task," by Sarason abstracted in this issue.)

Source: French, Elizabeth G., and Thomas, F. H. "The Relation of Achievement Motivation to Problem-Solving Effectiveness," *Journal of Abnormal and Social Psychology,* LVI (1958), 45-48.

differential use of incidental stimuli in problem solving as a function of creativity

Purpose: To investigate whether high-creative subjects rather than low- or middle-creative subjects (1) are more sensitive to environmental cues; and (2) have more ability to use these cues in problem solving situations.

Review: After 108 college students (41 males and 67 females) were administered Mednick's *Remote Associates Test (RAT)*, a test designed to measure creativity, they were assigned according to their test scores to a high-, middle-, or low-creative group. Several weeks after the administration of the *RAT*, subjects met in small groups and ". . . were told this part of the experiment was a study of 'memory under interference conditions'." In the first task, subjects were given 25 words to memorize (focal stimuli) while another list of 25 words was being played on a tape recorder (peripheral stimuli). In the second task, subjects were presented with 30 anagrams to be solved. Unknown to the subjects, however, ten of the anagrams solutions had previously appeared in the memorized list (focal incidental). "After the subjects had solved the 30 anagrams, they were given five minutes to recall as many as possible of the memorized list words."

An analysis of the results revealed that utilization of both the focal and peripheral incidental cues was highest for the high-creative group, followed by the middle- and low-creative groups. No significant differences in rote recall were found among the three creativity groups.

Conclusion: The investigators suggested that the results obtained in this experiment ". . . are attributable to differences in the reception and processing of stimuli by highly creative individuals relative to individuals of lower creativity." High-creative subjects seem to better retain prior stimulus experiences. To explain such a capacity, the investigators proposed two processes. First, high-creative subjects may attend to a wider range of stimuli than other subjects and thus receive more information which may influence their subsequent behavior. Second, high-creative subjects ". . . may screen out less of their 'irrelevant' past experience, i.e., memory traces which are remote and thus isolated by LC's [low-creative subjects] during problem solving remain available to HC's [high-creative subjects]."

Comment: The present study suggests that individual differences in perception and cognition may be preconditions for, rather than consequences of, creative behavior.

Source: Mendelsohn, G. A., and Griswold, Barbara B. "Differential Use of Incidental Stimuli in Problem Solving as a Function of Creativity," *Journal of Abnormal and Social Psychology*, LXVIII (1964), 431-436.

pressures to conform and logical problem solving

Purpose: To examine ". . . the effect of conformity pressures on the solution of logical syllogisms."

Review: Thirty-six male college students were randomly selected from a population of first- and second-year students to participate in this experiment. The experimental and control groups consisted respectively of 21 and 15 subjects. Four additional volunteers participated in the experiment as the "instructed majority." The "instructed majority" were told to behave as if they were subjects in an experiment, but the responses these volunteers gave to test items (logical syllogisms) were prearranged by the experimenters. Each experimental subject was brought to the room for individual testing after the four collaborators were already seated. Thus, the experimental subject was forced to take the remaining seat and was required to respond to the test syllogisms.

All subjects were told that the experiment was designed ". . . to measure logical problem solving ability." After subjects indicated that they understood the task involved in a practice syllogism, they heard 14 syllogisms read to them from a college textbook of symbolic logic. In the experimental sessions, correct responses were given by the "instructed majority" only to the first, second, fifth, tenth, and thirteenth items. No answers were given to control subjects. After the subject's responses were recorded, the experimenter privately inquired about the subject's reactions to the experiment.

In comparing the number of errors made to the syllogisms in the absence of group pressure to the number of errors made in the presence of such pressure, the experimental group erred on 49 percent of the trials whereas the control group erred on only .5 percent. The number of errors made by the experimental group ranged from one to nine, while only one subject in the control group made an error.

Conclusion: The investigators concluded that although the presented tasks were within the capacity of the subject's ability, under group pressure, conformity behavior — even to wrong answers — was substantial. The underlying cause for the conformity behavior came from anxiety, the investigators postulated. The anxiety apparently caused the thought processes of subjects to be disturbed. Consequently some subjects experienced "cognitive confusion" (distortion of the problem to fit the responses of the majority) while others suffered from "cognitive withdrawal" (an inability to follow the logic of the syllogisms and hence give the majority response).

Comment: Since anxiety appears to affect a subject's thought processes in a problem solving situation, it is likely to have critical effects on an individual's ability to learn in problem solving situations in school. The effects, however, are manifested differentially. Subjects react differently to their various levels of anxiety. A teacher should be aware that some students' behavior will be greatly affected by anxiety, whereas others will only be mildly affected.

Source: Rosenhan, David; De Wilde, Daniel; and McDougal, Stuart. "Pressure to Conform and Logical Problem Solving," *Psychological Reports*, XIII, (1963) 227-230.

the effects of anxiety and threat on the solution of a difficult task

Purpose: To examine the performance of high-, middle-, and low-anxious subjects while solving very difficult anagram problems.

Review: The investigator asserted that a better understanding of an individual's reactions to a difficult intellectual problem may be developed if, "... in addition to the difficulty and anxiety variables, the factor of the conditions under which performance takes place is better understood." In this investigation, the condition studied was the nature of the instructions administered to subjects immediately prior to performance on the anagram tasks.

Very difficult anagrams were selected from Sargent's list. All subjects were tested in groups ranging in size from 35 to 50. One-half of the 191 college subjects used in this study were told that their anagrams could easily be solved by an individual of average intelligence. The instructions were called the "personal threat condition" because the subjects quickly discovered that the anagrams were very difficult to solve. Under this condition, the investigator predicted that the performance of low-anxious subjects would be superior to the performance of high-anxious subjects. The remaining subjects were told that the anagram tasks were very difficult and very few subjects would finish the task. It was predicted that under this "nonthreat condition" there would be no significant difference between the performance of high- and low-anxious subjects.

Prior to and independent of the administration of the angram problems all subjects were administered the *Test Anxiety Scale (TAS)*, the *Lack of Protection Scale (LP)*, and the *Autobiographical Survey (AS)*. Also 91 of the subjects were administered the Bendig short form of the *Taylor Manifest Anxiety Scale (MAS)*.

On the *TAS*, low- and high-anxious group scores corresponded to approximately the lower and upper 30 percent of the *TAS* score distribution. The middle group scores corresponded to the remaining 40 percent of the distribution. On the *LP*, the subjects were divided into the three anxiety level categories using the same percentage cut-off points as in the *TAS*. Subjects were divided at the median on the MAS in order to form the high- and low-anxious groups.

An analysis of variance on the number of correct anagram solutions with the three levels of *TAS* and two levels of instruction revealed an interaction between test anxiety and instruction. Under the "personal threat condition," the middle and low *TAS* subjects performed at a higher level than the high *TAS* subjects. However, under the "nonthreat condition," the opposite results were obtained. An analysis for the *LP* revealed results identical to those obtained with the *TAS*.

Conclusion: Threat and nonthreat conditions differentially affected high-, middle-, and low-anxious subjects. Under the threat condition, high-anxious subjects performed at a lower level of proficiency than did low- and middle-anxious subjects. The opposite result emerged under the nonthreat condition. The investigators noted ". . . a condition which provides reassurance and consequently better performance for a high-anxious individual may actually serve to lower the motivational level and performance of less anxious individuals."

Comment: In view of the results of this investigation, it would appear that many intelligence, achievement, and aptitude tests have frequently been conducted under conditions of perceived personal threat. Thus, the ability of high-anxious subjects probably has been systematically underestimated due to interfering anxiety. On the other hand, in situations where low-anxious subjects have not perceived a test as threatening, they may be less motivated and thus their performance score will be lowered.

Source: Sarason, I. G. "The Effects of Anxiety and Threat on the Solution of a Difficult Task," *Journal of Abnormal and Social Psychology*, LXII (1962), 40-45.

problem solving as a function of children's defensiveness and parental behavior

Purpose: To determine how the presence and participation of the maternal parent affects her son's defensiveness in a problem solving situation.

Review: In this article, the investigators have reported the results of part of their ongoing research on the effects of parental behavior on the test performance of anxious and defensive children. The investigators have assumed that anxiety is an important component of the personality dynamics of both test anxious and defensive children.

In order to compare effects of high and low defensiveness, the experiment was designed so that the level of test anxiety was controlled. *The Defensiveness Scale for Children (DSC)*, *the Test Anxiety Scale for Children (TASC)*, and the *Lorge-Thorndike Intelligence Test (LT)* were administered to 299 fifth-grade boys representing the entire population of such boys in a Minneapolis-St. Paul school district. Only those boys with *LT* scores between 100 and 120 were considered in choosing the experimental sample. Boys with *TASC* and *DSC* scores below the fiftieth percentile were classified as low anxious-low defensive *(LD)*. Boys with *TASC* scores below the fiftieth percentile, and *DSC* scores above the seventy-ninth percentile were classified as low anxious-high defensive *(HD)*. From these groups, 16 LD boys and 16 HD boys were randomly selected.

The performance of the two groups was compared on the *Porteus Maze Test* taken with mothers absent, and on a parallel form of the *Porteus* with mothers present but not participating. A jigsaw puzzle test was also administered with mothers present, but here the mothers were told they could help in any way they liked if they felt like doing so. The mothers' behavior was recorded on a set of specially designed rating scales as they worked with their sons on the puzzle.

A series of statistical analyses were performed on the test and rating scale data. The results showed that HD boys made significantly more qualitative errors on the *Porteus Maze Test* than LD boys, but the presence of mothers did not affect the number of qualitative errors in either group. Quantitative errors on the maze test were related to the mothers' presence or absence. LD boys solved more mazes than HD boys in the mother-absent condition. With mothers present but not participating, HD boys performed slightly better than LD boys. On the jigsaw puzzle problem in which mothers were free to actively participate, the rating scales ". . . confirmed the expectation that mothers of LD boys would be verbally more supportive than mothers of HD boys," and LD boys showed a tendency to complete the task more quickly.

Conclusion: The investigators concluded that differences in maze performance were due to the intervening effects of defensiveness rather than to intellectual ability since subjects had been equated on intelligence. They further noted that quantitative differences tended to be functions of both the type of problem solving behavior required by the task, and environmental factors in the test situation.

Comment: Freer communication, both verbal and nonverbal, apparently exists between LD boys and mothers. In teaching situations, where children often place the teacher in the role of the mother, good teacher-pupil communication may be easier to establish with LD boys. However, the results suggest that a supportive teacher may facilitate the performance of HD boys especially when they are confronted with quantitative problems.

Source: Ruebash, R. B.; Byrum, M.; and Farnbam, L. J. "Problem Solving As a Function of Children's Defensiveness and Parental Behavior," *Journal of Abnormal and Social Psychology*, LXVII (1963), 355-362.

section V

sex differences in problem solving

Although very few experimental studies have been conducted which have systematically investigated the question of sex differences in problem solving behavior, traditionally, studies which have been made strongly suggest that male subjects are superior in problem solving ability. However, more recent experimentation by Raaheim and others, has not corroborated the results of the previous investigators, and indeed, Raaheim has found female subjects to be superior on certain tasks. One possible explanation which may account for the sex differences in problem solving ability may be "role appropriateness" of the problems which subjects are required to solve. Milton, for example, states that "when the characteristics of problems are altered so as to make them less appropriate to the masculine role, the sex differences in problem solving skill will be reduced."[1]

In this section, the first two studies investigate the question of sex differences in problem solving and some possible explanations for the differences. The final study reported the effects of strategy, sex, and age on problem solving behavior.

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[1] G. A. Milton, "Sex Differences in Problem Solving as a Function of Role Appropriateness of the Problem Content," *Psychological Reports*, V (1959), p. 705.

sex differences on problem solving tasks

Purpose: To investigate possible sex differences on three problem solving tasks.

Review: Although systematic studies of sex differences in problem solving behavior have been limited in number, several researchers have reported differences in favor of male subjects. However, Raaheim's previous research with high school students has failed to substantiate these results. In this study, problem solving tests constructed by the investigator were administered to both high school and university students.

The investigator developed two tests: (1) the *F-test* which measures an individual's ability to list uses or functions for a common object; and (2) the *O-test* which requires the listing of as many objects as possible that may serve the function of an implement found missing in a problem situation. Performance on both tests has been shown to correlate positively with success on practical construction problems, and the *F-test* has also correlated positively with high school students' scores on general intelligence tests.

Eighty-seven Norwegian high school students, 15 to 16 years old were given both the *F-test* and a Norweigan group test of general intelligence. The mean score on the *F-test* was 11.7 for both sexes, but more girls than boys obtained scores of less than 100 on the general intelligence test.

The university sample consisted of 26 males and 25 females obtained from an introductory psychology course at the University of Bergen in Norway. All subjects were first administered the *Mönnesland Intelligence test* which yielded the same mean raw scores for both sexes. They were then given the *O-test* on which females scored significantly higher than males. Scores by sex on the *O-test* were correlated with intelligence test scores, but neither coefficient was significant. The university students were also given a function-naming test. No significant differences between sexes were found on either correctness of problem solution or time spent in solution.

Conclusion: "Female subjects did as well as males on practical construction problems presented in writing. No sex difference was found on a function-naming test, but female subjects were found to be superior when the task was to list replacements for missing implements."

Comment: The results reported by Raaheim are in agreement with several recent studies of problem solving behavior (see Milton, "Sex Differences in Problem Solving as a Function of Role Appropriateness of the Problem Content," abstracted in this issue) which tend to show fewer male-female differences unless the problems were specifically oriented to masculine interests.

Source: Raaheim, Kjill. "Sex Differences on Problem Solving Tasks," *Scandinavian Journal of Psychology*, IV (1963), 161-164.

sex differences in problem solving as a function of role appropriateness of the problem content

Purpose: To determine if sex differences in problem solving skills are reduced when the characteristics of the problems are more appropriate to the feminine role.

Review: Previous experiments showing consistent sex differences in problem solving skills have utilized problems that were more appropriate to the masculine rather than the feminine role. Adaptations of a problem's content were developed by the investigator in order to modify the differences usually found in experimentation.

The subjects in the experiment were 24 male and 24 female undergraduates from the University of Colorado randomly chosen from all four class levels. No intelligence test data were utilized, but the grade point averages of the two groups were not significantly different.

The problems presented to the subjects were constructed in parallel pairs, one being a conventional type and one altered to fit the feminine role. Each subject was given a set of 20 parallel problems to solve, 10 with "masculine content" and 10 with "feminine content." A working time of 80 minutes was allotted for the set.

The data were analyzed by an analysis of variance, and the results indicated that men solved more problems correctly, regardless of the "appropriateness of content." The sex differences diminished significantly on the half of the problems which were "appropriate" to the feminine role as opposed to the half of the problems which were male appropriate.

Conclusion: "In order to achieve maximum results in either case [male or female], it seems advisable to frame . . . in content appropriate to the sex role."

Comment: Although the measurement of problem solving skills in women appears to be facilitated by orienting content to the feminine role, the fact that male subjects scored higher in total problems solved suggests that perhaps the problems with feminine content were still more appropriate to male problem solving ability.

Source: Milton, G. A. "Sex Differences in Problem Solving as a Function of Role Appropriateness of the Problem Content," *Psychological Reports*, V (1959), 705-708.

effects of strategy, sex, and age on conceptual behavior of elementary school children

Purpose: To investigate the effects of age, sex, and conservative or commonality strategies on concept-attainment problems.

Review: Ten males and ten females from each of grades five and six were presented with four conjunctive problems (all defining attributes of the concept must be presented) with two dimensions relevant for each. After arriving at the laboratory, subjects were told that the experiment they were going to participate in was concerned with how people learn. They were then presented with two sets of instructions. All subjects received a general set of directions which explained the construction of the stimulus materials on cards. After subjects demonstrated that they were familiar with the five dimensions of each card (e.g., border number, border continuity, figure number, figure color, and figure shape) they described each of the dimensions to the experimenter. Concepts or rules for classification were defined for the students by showing them the way cards could be grouped into categories possessing a common characteristic and those not possessing the characteristic. Subjects were then informed that they were to determine the rule which was exemplified by a group of stimulus cards, each of which was marked with a "yes" or "no." The special instructions for the commonality and conservative strategies were then read. The commonality strategy instructions directed subjects to attend to the "yes" cards in order to determine the concepts, whereas the conservative strategy instructions directed subjects to examine cards which did and did not belong to the group of cards exemplifying the concepts. The time taken to learn the concept successfully were recorded as well as which cards a subject used in the attainment problem.

An analysis of variance performed on the time-to-criterion scores revealed: (1) subjects directed to use the commonality strategy were more efficient than those using the conservative instructions; (2) fifth graders demonstrated more efficient solutions than sixth graders; (3) females were more efficient than males. A chi-square analysis of subjects' departures from instructional strategies indicated statistically significant preference among all subjects to use the commonality strategy.

Conclusion: From the results of this study, it appears that young children in the fifth- and sixth-grades have a distinct preference for the commonality strategy rather than the conservative strategy. The investigators concluded that ". . . the nature of the conservative strategy requires greater use of formal logic than does the commonality plan . . ." and hence confirms the Inhelder and Piaget theory (1958) that formal reasoning begins at age 12. The theory is further supported by the fact that sixth graders showed an inferior performance to fifth-graders, suggesting that sixth-graders showed more awareness of the ". . . greater complexity of the task and the combinatorial aspects of stimuli than did fifth-graders."

Comment: The findings of this study further reinforce the idea that individual differences in the use of problem solving strategies exist in an elementary school population. Teachers should be responsive to the differential strategies used by boys and girls at different ages.

Source: Tagatz, Glenn E. "Effects of Strategy, Sex, and Age on Conceptual Behavior of Elementary School Children," *Journal of Educational Psychology*, LVIII, No. 2 (1967), 103-109.

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